Cultural Considerations in Service Learning with American Indian Reservation Community Stakeholders

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Abstract— **In the process of designing engineered systems, it is not uncommon for engineers to underestimate or altogether ignore the societal and cultural context of the problem. This is particularly true when designs are developed to solve world problems; a lack of societal consideration leads to implementation failures when engineers from developed countries attempt to design solutions "for" people in developing countries rather than working with them. It has been increasingly recognized in literature that stakeholder participation is critical for designing sustainable solutions. However, translating social and cultural values and stakeholder participation into engineering education remains an elusive challenge for educators.**

A similar challenge exists with engineering design for American Indian Reservations; however, this challenge is amplified due to a long history of racial tensions, biases, and political oppression that leads to American Indian distrust of mainstream engineers. This work in progress describes an ongoing engineering design project that is designed to meet the needs of the Pine Ridge Indian Reservation (PRIR) while: a) challenging students at a mainstream university to design within an appropriate cultural context, b) incorporating stakeholder participation and 3) increasing opportunities and interest in Native American participation in engineering. Dialogue between community members of the Pine Ridge Indian Reservation (PRIR, where OLC is located), faculty and students of the Oglala Lakota College (OLC) Tribal College, and faculty and students at the South Dakota School of Mines and Technology (SDSMT) have identified that the PRIR community is interested in collaborating on the design, research, and testing of a sustainable, renewable-energy based food production system. The system should not only to meet the community needs for safe and healthy foods, but also serve as a potential source of economic development for the community. This project includes an extensive partnership and has a strong focus on achieving sustainable design and business development through a multi-disciplinary advisory team. Students from South Dakota School of Mines and Technology (SDSMT) have partnered with faculty and students from the Oglala Lakota College (OLC) on the functional design of a renewable-energy based structure for economic development. The design team is advised by faculty at both institutions, as well faculty and experts representing other synergistic projects on PRIR, including an on-going NSF engineering educational effort, the Native American Sustainable Housing Initiative (NASHI), based at University of Colorado Boulder (CU Boulder), to share climate station data and energy monitoring expertise, and Thunder Valley Community Development Corporation, a sustainable community grant holder located at Sharp's Corner, South Dakota, just 8 miles from the OLC campus, to share cultural knowledge and values and business development strategies. The paper describes the lessons learned by students and educators when consideration of culture and stakeholder investment become significant components in an engineering design.

Keywords—cultural considerations, design education, stakeholder participation, service learning, sustainable design

I. INTRODUCTION

In an increasingly globally connected world, it is well-recognized that effective sustainable design strategies must incorporate the needs of those most intimately affected by the design into all stages of the design process. Social and cultural values can best be incorporated through stakeholder participation [1]. Translating stakeholder participation and social and cultural values into practice remains a challenge for both practicing engineering professionals and engineering design educators. Ideally, concepts such as learning to listen to stakeholders and considering societal impacts should be incorporated into engineering design curriculum to emphasize to students that these are essential components of good design. Furthermore, when the design focus is on sustainability, there is a documented need for incorporation of diverse backgrounds in the development of solutions; at the same time, a focus on sustainability may have the effect of increasing diversity, through engagement of women and other underrepresented groups, in engineering fields [2]. Thus, a design project grounded in sustainability can serve as an important strategy to bridge multiple engineering educational goals.

Capstone design courses serve an important role in engineering curricula; they are the opportunity for students to show both a culmination and integration of the technical knowledge they have developed in their coursework. But as engineering programs work towards educating the engineer of 2020, a stronger emphasis on more holistically trained engineers has emerged [3]. The fact that ABET outcome h specifically states that engineers must have "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context," emphasizes this reality. And it can be argued that this is particularly important in Civil Engineering, the

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mainstay of sustainability curricula and the discipline that most directly impacts the public. The ASCE Body of Knowledge [4] highlights the need for engineers to understand the impact of their solutions with regards to society and culture.

Service learning is one method by which the impact of designs on society can be directly experienced by students and faculty. Service learning can be differentiated from community service or international outreach by the integration of altruism and pedagogy, as demonstrated by programs such as Programs, such as EPICS at Purdue University. As such, service learning programs and projects provide strong mechanisms for integrating the understanding of societal impact with technical problem solving, directly addressing the stated need for more socially aware and engaged engineers. Co-curricular activities, particularly those involving international experiences, often serve to develop more socially engaged engineers as well. There is a well-known pitfall of these activities – an attitude of "doing something for" a person, group or community. Instead, it is important that students and engineers recognize the importance of working with and even learning from the impacted populations.

A multidisciplinary senior design project at the South Dakota School of Mines and Technology (SDSMT) is robustly integrating concepts of sustainable design with an emphasis on stakeholder input, expectations and evaluation. The design project is focused on the meeting a critical need on the Pine Ridge Indian Reservation (PRIR), an Oglala Lakota Native American Reservation located in southern South Dakota. The project involves an extensive collaboration with stakeholder participation and cultural considerations as integral components in all stages of the design. The discussion of the design education process in the following focuses on the process developed through this project for the incorporation of stakeholders and social and cultural contexts of the design.

II. Design Education with Stakeholder Participation

Over the past 20 years SDSMT has offered multidisciplinary capstone design projects for engineering students. More than half of the engineering students now participate in a multidisciplinary senior design project. The students have learned how to integrate the mechanical, electrical and computer engineering aspects of a problem, but even though we may feel there is a difference in culture between the departments, the differences are not like the differences between the students at SDSMT and OLC. The engineering students have become adept at documenting the technical specifications for a "typical engineering project" but have difficulty in identifying the social needs.

In the curriculum and in capstone courses, the ideas of engineering design and design thinking are presented to the students, yet the idea of dealing with open ended, ill-posed problems is never easy for students. When posed with fairly standard engineering problems embedded in such cultural issues as the differences between life on the PRIR and life on a campus like SDSMT, students are faced with a much more difficult problem. In the context of capstone design curriculum, this translates to a different style of approaching a design problem and much more time needs to be spent in gaining trust of stakeholders, understanding the cultural context of the proposed design, and iteratively and collaboratively developing a final design with stakeholder input than is typical of more mainstream types of project designs.

In the development of a design project that seeks to engage and challenge students in a mainstream university, the incorporation of awareness of Lakota culture into the design inherently must begin with a partnership and the identification of a project need. For this project, a significant design need was identified by OLC faculty and Oglala Lakota Tribal Member to benefit the Pine Ridge Indian Reservation community. This followed several years of collaborations between a tribal college, the Oglala Lakota College (OLC) and SDSMT through an NSF-funded Pre-Engineering Educational Collaboration (Oglala Lakota College/South Dakota State University/South Dakota School of Mines and Technology Pre-Engineering Education Collaborative, OSSPEEC) and the Native American Sustainable Housing Initiative (NASHI, University of Colorado Boulder. Specifically, a sustainable food production system with economic development potential was identified as a design need; the PRIR is classified by the US Department of Agriculture (USDA) as a "food desert," meaning that the access within the community to healthy, affordable foods is limited [5] and because the PRIR is also characterized by low income levels [6], In September 2013, this became an interdisciplinary senior capstone design project for six students at SDSMT: one electrical, three mechanical, and two civil/environmental students

Team member Wilson visited SDSMT in September 2013 to meet with the assembled design team. He spoke openly with the students about the historic mistrust that many tribal members have with regards to designs created outside of their culture. Much of this mistrust stems from a history of non-tribal engineers who create "designs for" Lakota people without a context of the culture rather than "designs with," where the end-users are engaged in the design process. The students learned that for their design to be successful, they would need to engage in collaborative discussions about the project throughout all stages of their design and that they would need to develop awareness of Lakota culture in the process. The design team developed a project website using the Piazza learning system platform, sharing access with SDSMT and OLC faculty advisers, to information sharing as part of their strategy for stakeholder participation.

In October 2013, the design team and SDSMT faculty advisors visited the OLC campus in Kyle, SD, on the PRIR, to promote their learning about the societal and cultural context of their design. The students met with OLC faculty there and also visited the sites for nearby collaborative sustainable development projects, the Thunder Valley Community Development Corporation office and a net-zero energy

research home developed through the NASHI program. A visit to the grocery store in Kyle gave students the chance to witness first-hand the lack of available healthy produce and the high prices for produce in an economically depressed region that result in the classification of PRIR as a food desert. The importance of the design in terms of its potential impact to the community motivated the students in their design.

In November 2013, the students discussed their project goals, early analyses, and reviews of their design alternatives in a "preliminary design review" presentation at OLC. Approximately 15 faculty, students, and community members attended the presentation. The session was very interactive, and promoted shared dialogue to refine their design goals and objectives, select a design alternative for further analysis, and to incorporate Lakota traditional knowledge and culture into the design process.

After the further design work, OLC faculty advisers and their students visited SDSMT's campus in April 2013 for a more comprehensive presentation of the proposed design. A total of 25 faculty and students from PRIR visited the campus, listened to a presentation of the design and provided feedback for the design team to further refine their designs. The entire collaborative group ate lunch and attended a class session for a multidisciplinary sophomore design class that focused on product development and the development of business plans for entrepreneurial ventures. During this class session, students were shown an example business plan for a hoophouse [7]; this became the final design selection for the production of local produce on the PRIR for the design project. Students from both SDSMT and OLC were shown this and used it for reflection on the food production as an entrepreneurial venture on the PRIR.

The visits to the PRIR were effective in providing both sides of the societal impact for the design students. On one hand, the visit in April 2014 was essential for "selling" the design to the stakeholders and was thus an essential component of the project's success. But the visits also informed the students of the specific needs and culture of the stakeholders. This helped meet the goal of understanding and learning from stakeholders as well as communicating to and gaining buy-in from them. The design team completed their capstone course requirements in May 2014 and provided their final design specifications to the OLC partners for construction.

III. Preliminary Results

This project has resulted in many lessons learned by both the students and the advising faculty. With regard to cultural considerations, an interesting outcome in students' cultural awareness was attained. At the start of the project, the students gave their team a name, The Green Team, which they translated into the Lakota language as "Owansila Zi." When the students presented their preliminary design at OLC, their audience, which included Lakota language speakers, explained that the term "green," which is used in mainstream American culture as synonymous with "environmental" or "sustainable" design does not have the same meaning in the Lakota language. In the native Lakota language, there is no equivalent word to even express the idea of "sustainability," because the Lakota culture is deeply connected to the land and people;[7] stewardship for land and people is ingrained in the Lakota way of life, and is not an afterthought, as it often is in mainstream American culture. This is an important distinction in understanding Lakota culture and how it should impact design.

Mutual visits to each other's campuses by SDSMT and OLC cohorts were essential for building trust, exchanging knowledge, promoting dialogue, and incorporating stakeholders into the design process at all stages of the design. Though many meetings incorporated semi-formal presentations, the design team was careful to stress that feedback and interruptions at any stage of the presentation were welcome. It was observed that open dialogue was promoted most effectively in a relaxed setting, in which sharing food, coffee, and jokes were important aspects of the shared design experience. Also, the creation of a Piazza learning system platform (http://www.piazza.com) for the design project that included faculty and students from SDSMT and OLC was an important tool for sharing information and building trust and dialogue.

A striking lesson learned through this project is that the development of a design that includes stakeholder participation progressed much more slowly than typical design projects, since it required multiple visits, meetings, and discussions between the design team and stakeholders in order to fully address the cultural and societal implications of the design. As a result, the academic year was not a long enough time frame to design and construct a prototype system which was the original intent of the design project. Thus, a modified design objective shifted from the construction of a full-scale prototype to a small-scale educational demonstration prototype, which included working sensors for future monitoring research for the design team's final requirements.

Also, due to political and social structure on PRIR that was not well-understood by mainstream engineers, the ultimate site location choice and construction of the prototype simply took patience. Thus, construction of the full-scale design shifted from April 2014 to the summer of 2014, with OLC construction students and a new team of undergraduate engineering students responsible for the project's continuation. Ultimately, a location on the OLC's campus near student housing was selected, in order to benefit from the visibility of the hoophouse to the community, and particularly for its visibility and proximity to K-12 students for outreach programs. At the PRIR, K-12 outreach education is considered an ideal audience, since over 50% of population on PRIR is under age 19 [8].

IV. Work to Be Done

In the summer of 2014, following completion of the first stage of design and construction of a system prototype, OLC

and SDSMT students will be engaged in the construction, monitoring, testing of the design through a synergistic NSF-funded project. The prototypes will serve as a case study for "project based service learning" (PBSL) through the collaborative OSSPEEC project through which Native American students will conduct research and monitoring related to the design in an effort to engage students and increase participation in engineering disciplines. Their research will be provided to a second year's multidisciplinary senior design project,

In the second year, the 2014-2015 academic year, students and this program will be assessed using several methods. Rubrics to address the engineering aspects as typical classroom grading will be included. All SDSMT students now take the Global Perspectives Inventory (GPI) [11] survey. Students complete this survey three times during their four years of college so there is a pre-post evaluation of development in their thinking in terms of global perspective. The Reasoning about Current Issues (RCI) [12] will be administered to students at SDSMT as well in their first and fourth years to get a pre- and post-evaluation of their reflective thinking. Both of these assessments have been shown to have reasonable validity. Both address key issues in dealing with design problems involving the complexity of crossing and blending cultures. Students working in the project team will be assessed pre-and post-completion of their capstone design course.

Most importantly, acceptance and adaptation of the design by residents of the PRIR will also serve as assessment tool of the design process developed here for the incorporation of stakeholder participation.

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